Experimental data supports the interactive development of language and technology

Philip Guelpa
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Two of the most fundamental questions in human evolution are how technology and language developed. Each is essential to the human mode of adaptation, culture, which is learned behavior based on abstract thought.

In recent years, anthropological research has increasingly indicated that the evolution of the capacities for technology and language are closely linked. Research reported in 2013 demonstrated that there is an overlap between the centers of the brain involved in speech and those that control the actions necessary for stone tool production (see "Evolutionary links between the development of language and stone tool technology"). This suggests that the mental operations necessary in the manufacture of tools and in linguistic utterances are closely linked and may have developed together.

New research published in the scientific journal *Nature Communications* provides further support for the proposition that language and stone tool production did, in fact, "co-evolve."

Unfortunately, the evolution of language and the cognitive capabilities that it represents do not leave direct physical evidence in the paleontological or the archaeological record (words and ideas do not fossilize). However, the record of the development of stone tool technology is preserved, and can serve as a proxy indicator of the mental sophistication of its practitioners.

Using a well-designed experiment, an international team of researchers in psychology, archaeology, and anthropology, led by Thomas Morgan of the University of California, Berkeley and the University of St. Andrews, was able to gauge the level of communication skills that would have been necessary to effectively pass on the knowledge of how to make stone tools from one generation to the next.

The earliest known stone tools belong to what is referred to as "Oldowan" technology, dated to at least 2.5 million years ago, and thought to be associated with the earliest member of the genus *Homo* – *Homo habilis*. This technology first appeared in Africa, but was subsequently spread to parts of Europe and Asia as more advanced early humans, *Homo erectus* and/or closely related species, spread across much of the Old World.

Oldowan technology consisted of the removal of flakes from a large pebble or cobble, known as a core, made of materials such as flint, using another pebble or cobble as a hammer, usually of a different material such as sandstone or quartzite. The resulting flakes had sharp edges which could be used for cutting or scraping, in such activities as butchering or processing of plant materials.

The production of such flakes involves a range of cognitive abilities, such as how to choose suitable materials for both the core and the hammer, knowledge of fracture mechanics, and the skill to effectively strike the core with the hammer at the proper angle and with the necessary level of force to remove a flake with the desired characteristics.

This is not easily accomplished. It is beyond the capability of any non-human ape. The procedure for making stone tools, known as knapping, requires training and practice to achieve proficiency, even for modern humans. The logical inference is that the production of Oldowan tools had to be taught.

As impressive as Oldowan technology is, in comparison to the capabilities of any other animal, it was in fact, only the earliest and simplest of a series of increasingly sophisticated technologies that mark the evolution of human skill and cognitive abilities.

The next major advance known in the archaeological record came with the appearance of what is called Acheulean technology, approximately 1.7 million years ago. Acheulean tools were manufactured by *Homo erectus*, and are found across large portions of Africa, Europe, and Asia, though Oldowan type tools continued to be used as well, and in some places exclusively so.

Whereas Oldowan tools are primarily flakes, though the cores may have been used to some degree as well, the Acheulean toolkit includes both cores and flakes. The production of the Acheulean core tool, known as a "hand axe," represents a level of technical skill as well as an aesthetic sensibility, as expressed in a concern for symmetry and fineness of workmanship, which are qualitatively superior to those exhibited by Oldowan tool makers.

Hence, it is reasonably inferred that Acheulean technology required a set of cognitive skills similarly in advance of those possessed by the makers of Oldowan tools. Furthermore, the greater consistency in form exhibited in the manufacture of Acheulean hand axes, as compared to the amorphous Oldowan cores, suggests that the makers were following a stylistic tradition that was socially determined and passed from one generation to the next.

The authors of the *Nature Communications* article posed the question: what form of communication would have been necessary to properly train novices in Oldowan production technology and how would that differ from the methods needed to transmit Acheulean methods? Would the latter necessitate greater language skills than the former?

The experiment consisted of teaching 184 adults how to make Oldowan tools using a variety of instructional methods. The participants were broken into groups. With each group using a different method of communication, successive members would attempt to pass on the Oldowan technique to the next member, forming a chain of instruction.

The teaching methods employed included – (1) reverse engineering (inferring the production method only by viewing previously completed examples), (2) imitation/emulation (watching someone else, but without any form of active instruction, (3) basic teaching, (4) gestural teaching (use of pointing and other motions, but without verbal communication), and (5) verbal teaching.

Using six measures of performance, the researchers found that the results were significantly better for the three active teaching methods, as opposed to the two passive forms. The improvement was especially marked for verbal teaching. The use of language improved the results by a factor of two over reverse engineering. Imitation/emulation did not show a significant increase in quality of production over reverse engineering.

Based on these findings, the researchers conclude that a reliance on Oldowan tools by early hominids would have created a selective advantage for the use of active teaching methods and that increasingly sophisticated forms of teaching progressively improved the quality of information transmission. This latter observation suggests, but does not prove, a sequence of cognitive development.

The selection pressure would have affected both genetic and cultural evolution. Groups of *Homo habilis* with greater genetic capacities for teaching and learning, and hence a greater ability to effectively pass on the cultural tradition of Oldowan tool making, would have had improved survival prospects over other groups that did not, hence natural selection would favor them. Furthermore, improved transmission of innovations in tool manufacture due to more effective teaching would accelerate technological advancement.

It should be noted that, although chimpanzees do manufacture several forms of very primitive tools, the knowledge of how to make such tools is passed on purely by imitation/emulation. No active teaching has ever been observed.

The researchers further conclude that the appearance of Acheulean technology, which, as indicated above, was significantly more sophisticated than Oldowan, would have required verbal teaching, in other words, language. They propose that the stagnation of technological development, marked by the roughly 700,000-year-long span between the first appearance of Oldowan and the emergence of Acheulean technology, represents the time period during which selective pressures were operating to promote the development of language as well as the development of other necessary cognitive and social structures.

Reliance on tools would have created a selective advantage for the development of language to improve the quality of cultural transmission. Language and the cognitive capacities it entails, in turn, would have permitted the invention and perfection of increasingly sophisticated tools. Better tools would then have made humans even more dependent on the use of technology, and so on. Although the authors do not use the term, this process is clearly dialectical. Each opposite both modifies and is modified by the other, and together this interaction propels the whole to a qualitatively new unity.

Both Charles Darwin and Fredrick Engels proposed that the development of language and of technology were linked. While not definitive by itself, this experiment, along with the earlier research cited above, supports that contention. Furthermore, it demonstrates the ability of the scientific method, as applied in this case by the use of experimental archaeology, to reveal new information about the past, such as the development of language, which has previously been thought to be irretrievable. Furthermore, it provides firm support for the primacy of material factors in the development of human cognition.